T-4

Presentation

to the

Land Working Group

of the

MODIS Science Team

from

MCST (MODIS Characterization Support Team)

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1615 Tuesday, 14 April 1992

Management Conference Center, Bldg 8 , Goddard Space Flight Center

Attachment 4.1

Overview of Part 1
of
MCST Presentation to Land Working Group

Land-Related MODIS Geometric Requirements

- MODIS Pointing Knowledge Requirement Memo
- Salomonson and Barker Georeferencing Talk
- MCST Simulated Band-to-Band Sensitivity
  - Mis-Registrated Full-Scene Histograms
- MCST Simulated Scene/Pointing Sensitivity
- MODIS Pointing Knowledge Requirements
- MODIS Pointing Knowledge Goals

Back-Up Charts on Geometric Requirments

- Definitions Related to Geometric Requirements
- Error Budget from SBRC
  - Band-to-Band
  - Pointing Knowledge
- Salomonson and Barker Georeferencing Text

MODIS Pointing Knowledge Requirement Memo

Posted: Mon, Mar 23, 1992 10:33 AM EST **Msg: PJJC-1705-7251**
From: JBARKER
To: KANDERSON
CC: wbarnes, bguenther, mdking, vsalomonson, rweber
Subj: MODIS Pointing Knowledge Requirement

20 March 1992
To: Ken Anderson/EOS-PM MODIS/422
From: John Barker/MCST/925
Subject: MODIS Pointing Knowledge Requirement

Yes, MODIS does require at least 108 arc sec accuracy for the spacecraft component of the pointing knowledge, and in fact, it has been our assumption that with the smaller EOS-AM and EOS-PM platforms that you would be able to further reduce this requirement beyond the 108 arc sec that was dictated to us from the original EOS-A platform people.

The rationale for a requirement of at least 108 arc sec pointing knowledge is summarized in a recent paper by Vince Salomonson and myself entitled "EOS Moderate Resolution Imaging Spectroradiometer: Phase C/D Status and Comments on Calibration and Georeferencing Approaches," which was given as a talk at the 15 Annual AAS Guidance and Control Conference in February 1992. I will send you a copy of this by EMAIL, and I will also send a hardcopy directly through the regular mail.

One of the primary reasons for the requirement is that the between-instrument masking utility products for clouds and land, which will be automatically applied to all MODIS data, and to many of the inputs for products from instruments such as AIRS and MISR, requires geolocation without any reference to ground control points.

We are holding a MODIS Science Team meeting from April 13th through 16th. If you require any specific validation of our requirements, this should be examined during this meeting. We would like to know what you might need to support this platform requirement, if anything.

cc:

Bill Barnes/970	Mike King/913
Barbara Grant/925	Vince Salomonson/900
Bruce Guenther/925	Dick Weber/422
Chris Justice/923	

AAS 92- 004

EOS MODERATE RESOLUTION IMAGING SPECTRORADIOMETER: PHASE C/D STATUS AND COMMENTS ON CALIBRATION AND GEOREFERENCING APPROACHES

Vincent V. Salomonson and John L. Barker

15th ANNUAL AAS GUIDANCE AND CONTROL CONFERENCE

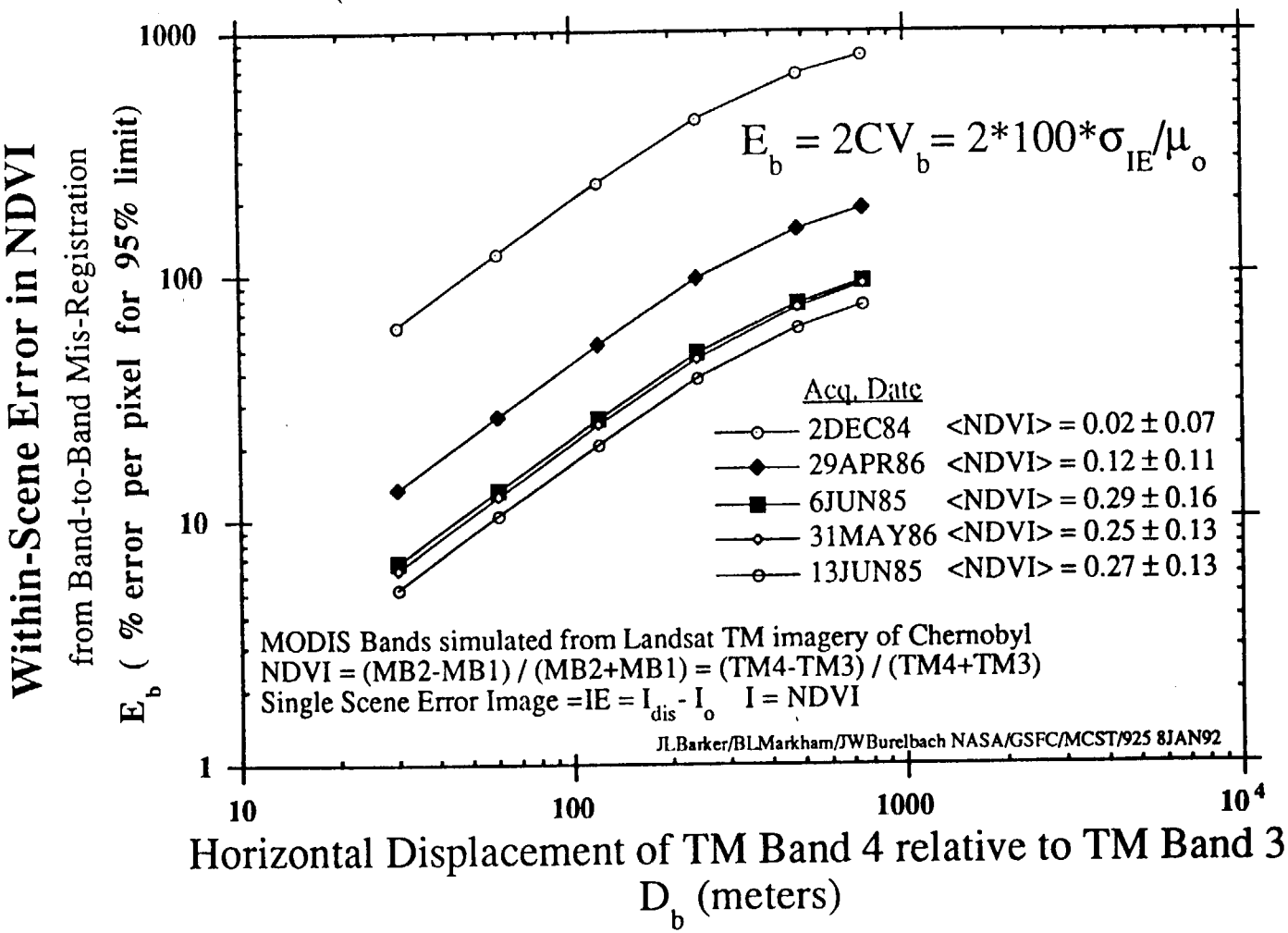
February 8-12, 1992
Keystone, Colorado

PUBLICATIONS OFFICE, P. O. BOX 28130 - SAN DIEGO, CALIFORNIA 92128

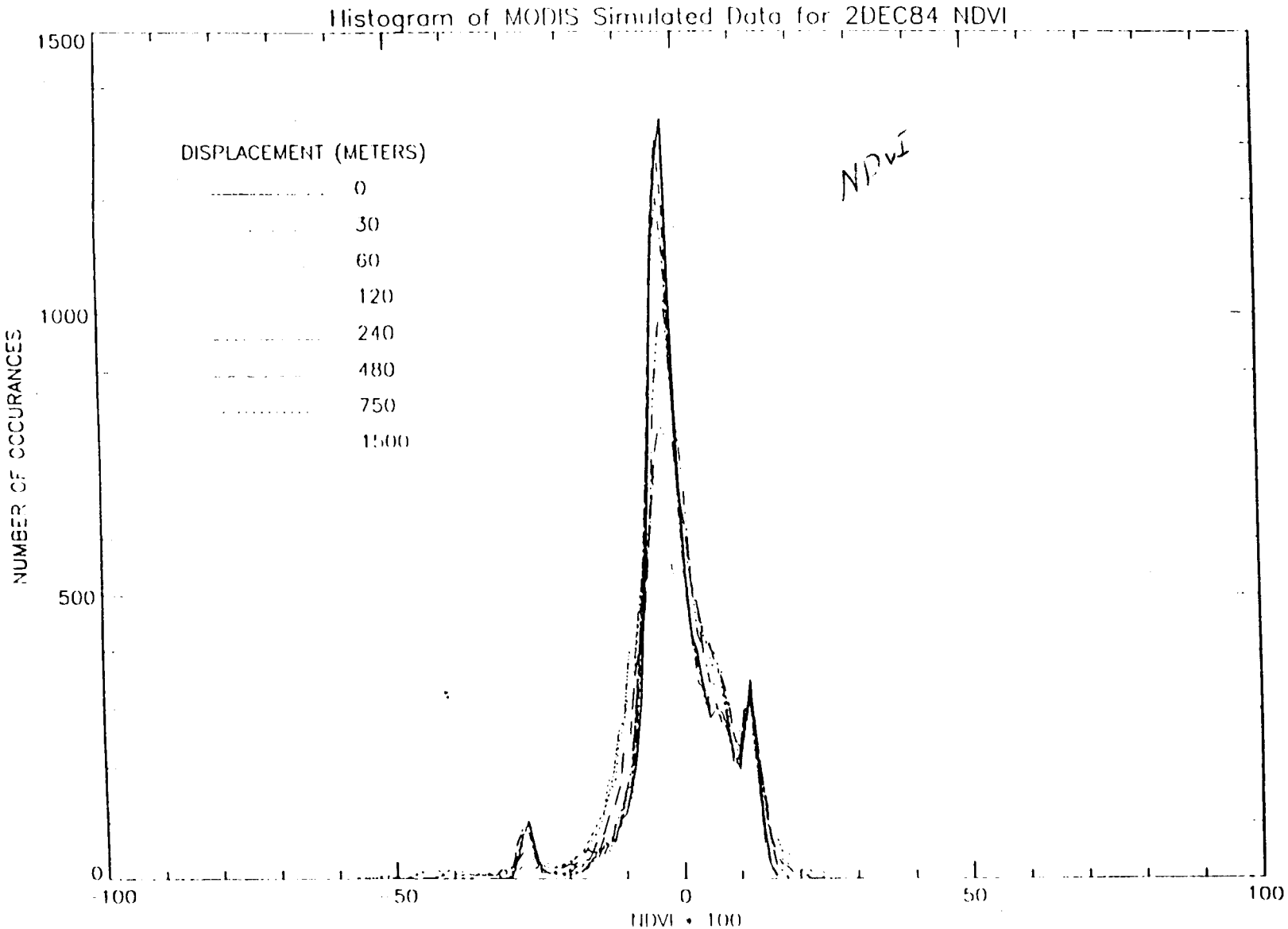
Simulated MODIS-N Sensitivity Studies by MCST

MODIS-N Band-to-Band Registration Sensitivity

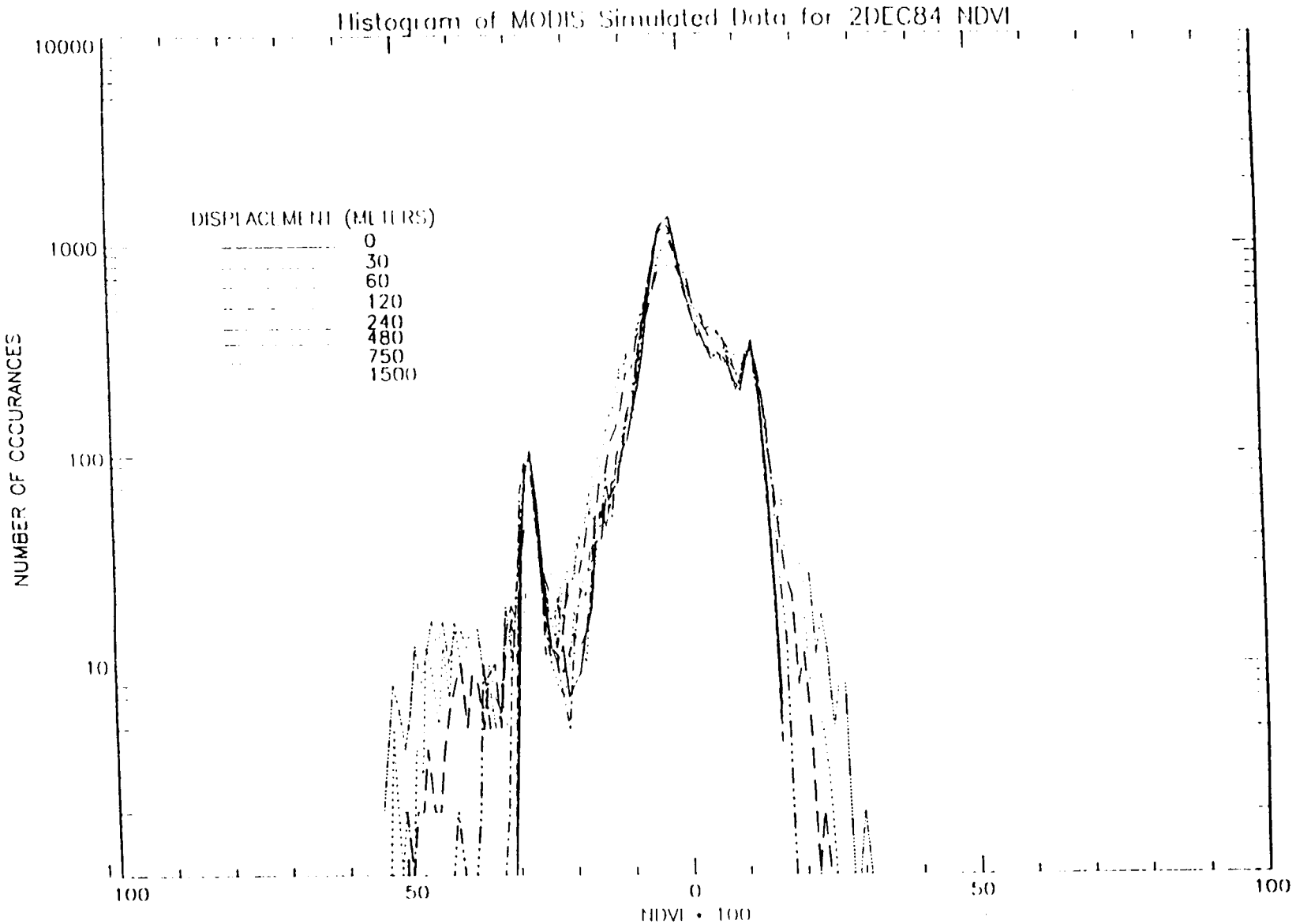
for measuring an NDVI vegetation index over land within a single scene
(MODIS-N Band-to-Band Registration Requirement is 0.1 Pixel)



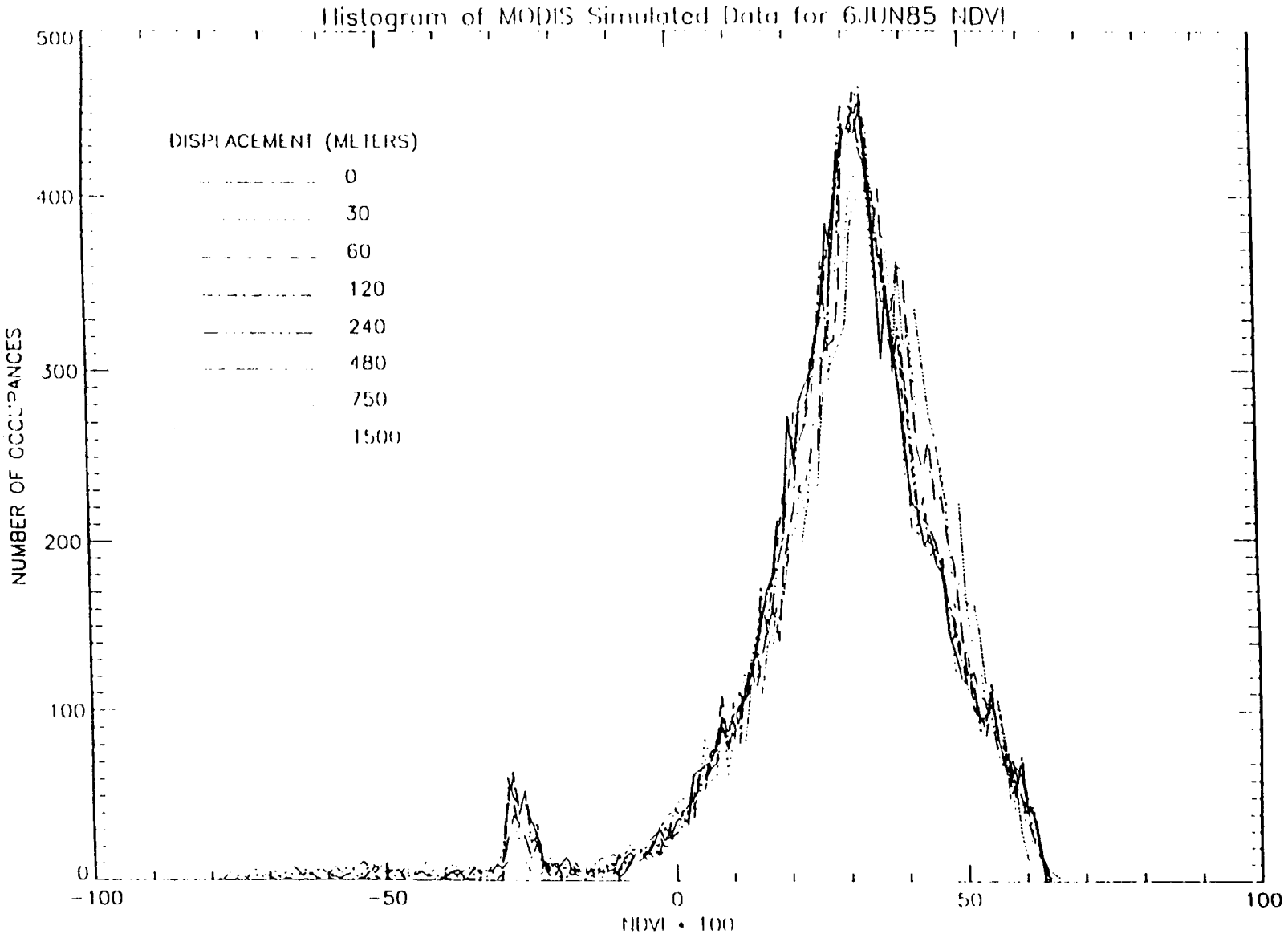
MCST Simulated MODIS Full-Scene Histogram
indicating Effects of Band-to-Band Mis-Registration



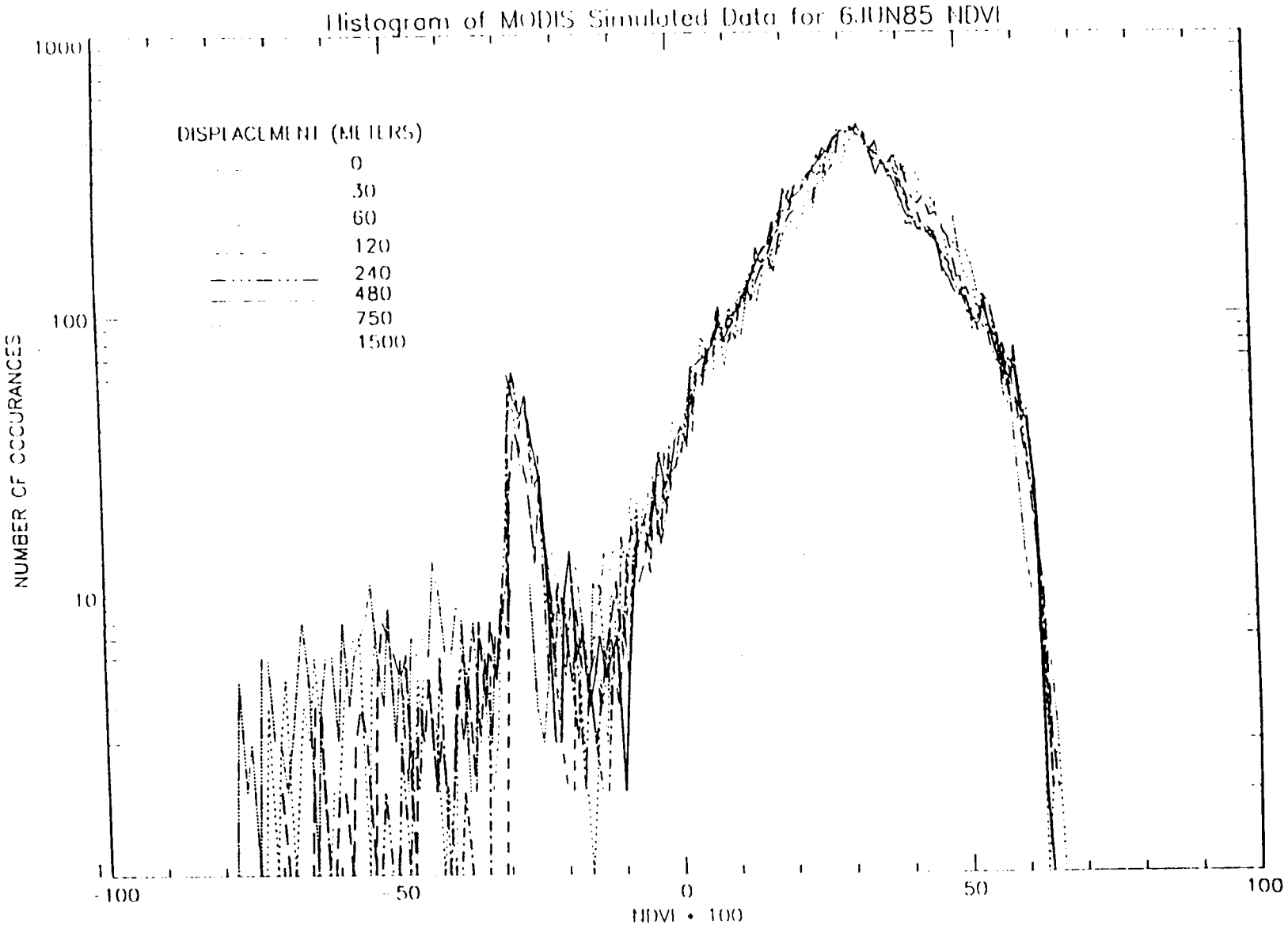
MCST Simulated MODIS Full-Scene Histogram
indicating Effects of Band-to-Band Mis-Registration



MCST Simulated MODIS Full-Scene Histogram
indicating Effects of Band-to-Band Mis-Registration



MCST Simulated MODIS Full-Scene Histogram
indicating Effects of Band-to-Band Mis-Registration

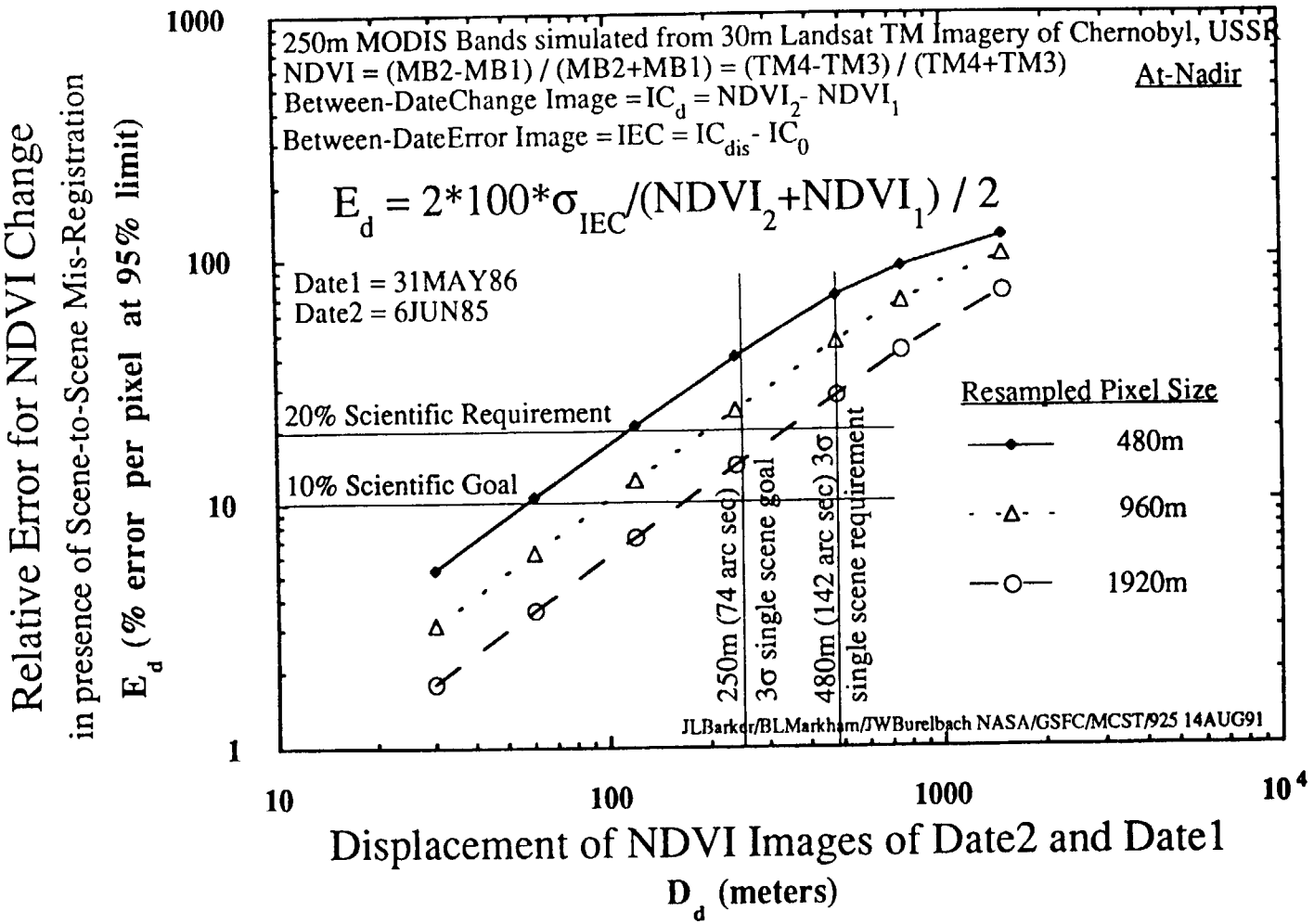


Simulated MODIS-N Sensitivity Studies by MCST

MODIS Scene-to-Scene Registration Sensitivity

for measuring an NDVI vegetation index over land

for examining combined Instrument and Observatory Pointing Knowledge Requirements



MODIS Geometry Requirements Table
from response to GE questionnaire

Parameter	Reference Axis	MODIS Instrument Requirement		EOS Observatory Requirement		End-to-End Requirement		RT or PP (Note 1)
Pointing Knowledge		arc seconds	meters at Nadir	arc seconds	meters at Nadir	arc seconds	meters at Nadir	
	x	90	(310)	108 ??	(370)	(141)	(480)	PP (Note 3)
	y	90	(310)	108	(370)	(141)	(480)	PP (Note 3)
	z	90	(310)	108	(370)	(141)	(480)	PP (Note 3)
Pointing Accuracy		arc seconds	meters at Nadir	arc seconds	meters at Nadir	arc seconds	meters at Nadir	
	x	(2550)	(8700)	(2550)	(8700)	3600	(12000)	RT
	y	(2550)	(8700)	(2550)	(8700)	3600	(12000)	RT
	z	(2550)	(8700)	(2550)	(8700)	3600	(12000)	RT
Stability		Arc Seconds per second	Meters per second	Arc Seconds per second	Meters per second	Arc Seconds per second	Meters per second	
	x	(510)	(1740)	(510)	(1750)	720	(2460)	RT
	y	(20)	(70)	(20)	(70)	28	(96)	RT
	z	(20)	(70)	(20)	(70)	720	(2460)	RT

Note 1: Specify RT for real-time or PP for post-processed performance.
Note 2: List maximum peak-to-peak excursion in arcseconds and corresponding time period. All periods of interest should be listed. For example, 8 arcseconds in 10 seconds and 15 arcseconds in 500 seconds is the form of the response required.
Note 3: To be available at the same time as Level-0 instrument data.
( ) Parentheses indicate derived numbers.

MODIS Geometry Goal Table
from response to GE questionnaire

Parameter	Reference Axis	MODIS Instrument Goal		EOS Observatory Goal		End-to-End		RT or PP (Note 1)
Pointing Knowledge		arc seconds	meters at Nadir	arc seconds	meters at Nadir	arc seconds	meters at Nadir	
	x	(50)	(175)	(50)	(175)	(73)	250	PP (Note 3)
	y	(50)	(175)	(50)	(175)	(73)	250	PP (Note 3)
	z	(50)	(175)	(50)	(175)	(73)	250	PP (Note 3)
Pointing Accuracy		arc seconds	meters at Nadir	arc seconds	meters at Nadir	arc seconds	meters at Nadir	
	x	(2550)	(8700)	(2550)	(8700)	3600	(12000)	RT
	y	(2550)	(8700)	(2550)	(8700)	3600	(12000)	RT
	z	(2550)	(8700)	(2550)	(8700)	3600	(12000)	RT
Stability		Arc Seconds per second	Meters per second	Arc Seconds per second	Meters per second	Arc Seconds per second	Meters per second	
	x	TBD	TBD	TBD	TBD	TBD	TBD	RT
	y	TBD	TBD	TBD	TBD	TBD	TBD	RT
	z	TBD	TBD	TBD	TBD	TBD	TBD	RT

Note 1: Specify RT for real-time or PP for post-processed performance.
Note 2: List maximum peak-to-peak excursion in arcseconds and corresponding time period. All periods of interest should be listed. For example, 8 arcseconds in 10 seconds and 15 arcseconds in 500 seconds is the form of the response required.
Note 3: To be available at the same time as Level-0 instrument data.
( ) Parentheses indicate derived numbers.

Overview of Part 2
of
MCST Presentation to Land Working Group

Land-Related Science Team Objectives
MCST Priorities
MODIS/MCST Utility Data Products
- Texture Algorithm
  - Objectives and Approach
- Classification Overlay/Masking Algorithm
  - Objectives
  - Phased Development

MCST-Related MODIS Scene Simulation Activities
- Requirements, Properties and Approach
- Atmospheric Models
- Global Site Selection
- Simulated MODIS U. S. Land/Water Mask

Suggested MCST Land-Related WG Action

Science Team Objectives and Suggested Land WG Action

1. **Re-evaluate selection of science algorithms**
   as a result of current instrument selection.
   Suggested Action:
   Need Land WG endorsement of up-dated list of utility products.

2. **Report on current status of algorithm development.**
   Suggested Action:
   Indicate utility products are under development

3. **Identify the planned level of algorithm development**
   in light of current budget and time constraints.
   Suggested Action:
   Confirm 1990/1991 MCST lower priority
   for land-related utility products than for calibration-related products

4. **Your algorithm development plans and schedule for development.**
   Suggested Action:
   Develop schedule for peer review and delivery of algorithms

5. **Your current perception of planned stage of algorithm development**
   before entrusting to the Science Data Support Team (MSDST)
   Suggested Action:
   Indicate intent to provide peer-reviewed and working S/W to MSDST

Priority Order of MCST-Related Activities

unchanged from
1990 and 1991 MODIS Science Team Meetings

1. Instrument-Related Characterization/Calibration

2. Algorithms, Software and Hardware
   for EOC/MCST Monitoring of In-Orbit Data

3. **Utility Products**

4. **Simulated MODIS Imagery**

5. **Cooperative Team Member and MCST**
   Discipline-Related Product Sensitivity to Calibration

At-Launch MODIS Utility Data Products*
MCST Product Generation Responsibilities

Derived Level-2 Imagery

Three level-2 image spatial products, i. e. for sets of 250, 500, and 1000 m bands

Texture Products

Sixteen-Bit Radiometric Spatial Heterogeneity/Texture Image
derived from one or both of the 250 m MODIS bands

One-Bit "Pure Pixel" Binary Mask

Classification Overlay Map

Classification Mask of Homogeneous Areas, including classes for:

"Definitely" Cloud	"Definitely" Not Cloud
"Definitely" Shadow	"Definitely" Not Shadow
"Definitely" Water	"Definitely" Not Water
"Definitely" Snow/Ice	"Definitely" Not Snow/Ice
"Definitely" Vegetation	"Definitely" Not Vegetation
"Definitely" Land	"Definitely" Not Land
Image Terminator Line	Calculated Terminator Line

* At-launch products will be up-dated after launch
to go from radiance-based to reflectance and temporally-based algorithms,
including extension to critical level-3 products.

MODIS/MCST Land Data Products*

Discipline Group	Parameter :: Qualifier	Investigator	Time	Original Product Name (from Investigator)
LAND	Texture::MODIS Level-2	Salomonson/Barker	AL	Utility Algorithm with Strahler
LAND	Texture::MODIS Level-3	Salomonson/Barker	PL	Utility Algorithm with Strahler
LAND	Classification::MODIS Masks Level-2	Salomonson/Barker	AL	Cloud/Snow/Land/Water Utility Mask with Hall
LAND	Classification::MODIS Masks Level-3	Salomonson/Barker	PL	Cloud/Snow/Land/Water Utility Mask with Hall

* As currently carried in the EOS Science Data Product Database (Yun Chi Lu/936)

* The question of whether there are unique EOS-AM, EOS-PM or combined EOS-AM/EOS-PM land data products has not been examined.

Are there any other MODIS Team Members from the Land Discipline who wish to collaborate on the two utility products?

MODIS/MCST Texture Utility Algorithm Objectives and Approach

Create un-resampled level-2 data products for the three MODIS spatial resolutions namely, 250, 500 and 1000 m

Three 16-Bit Texture Products

- Develop spatial texture measure using 250m bands
- Calculate geophysically based texture measures
  - perhaps standard deviation of NDVI

Three 1-Bit Texture "Pure Pixel" Masks

- Label each pixel as "pure" or mixed
  - by thresholding of texture product

Classification Overlay/Masking Utility Algorithm Objectives and Priorities

Create un-resampled level-2 data products
as classification overlay masks
for the three MODIS spatial resolutions
namely, 250, 500 and 1000 m

The priority order for mask generation is

1. Clouds
2. Snow/Ice
   to provide the input for at-launch snow cover product
3. Water
4. Land, vegetated and non-vegetated
5. Image Terminator Line
   both observed by thresholding on imagery
   and by calculation of known Sun/Satellite positions
6. Cloud Shadows
   calculated from the cloud mask and cloud height

Classification Overlay/Masking Utility Algorithm Key Elements in Phased Developmental Approach

Pre-Launch Phase

- Level-2 Exoatmospheric Reflectance used as Input
- Texture Mask to identify Spectral Signatures from "Pure Pixels"
- Unsupervised Classification

Post-Launch Phase

- Reflectance-Based
  - after application of MODIS Atmsopheric Utility
    - Directional
    - Bidirectional
- Time-Dependent Classification Use of Prior Classifications
  - to Change A Priori Probablitites
  - to Provide Fitting Parameters for Predictive Models
- Regional Validation based on ASTER and Landsat TM Imagery
- Global Comparison to AVHRR Cover Maps

MCST-Related MODIS Scene Simulation Activities
Requirements for Simulated Data Sets

Simulated data sets are required to develop, characterize and validate :

- Calibration algorithms and trade-off studies
  - for both the instrument and platform
- Science and utility algorithms
  - for information extraction
- Operational software for the processing algoriths
  - for the ground processing/data reduction computers

Simulated data sets can provide only a limited representation
of the actual temporal data sets
that will be acquired by the MODIS instruments in space

- i. e., they are **not** intended for a priori
  - representative characterization of global processes

MCST-Related MODIS Scene Simulation Activities
Desired Properties of the Simulated Data Sets

Be derivable conveniently, cost-effectively and in a timely manner

Cover the spectral, radiometric , geometric, field-of-view, temporal
and other operational ranges of the MODIS instruments, including
typical or pseudo-realistic cases, and
limiting or extreme cases

Be structured for parametric sensitivity studies to readily reveal behavioral
characteristics of system under consideration

Allow scene modification/creation for unanticipated needs

Provide for easy validation against well understood existing real datasets
(the simulated data **correspondence** principle)

Be complete enought to allow for stressing all pathways in the software

MCST-Related MODIS Scene Simulation Activities
Approach to Simulating Data Sets

Synthetically and theoretically derived structured scenes
- Well defined geometric patterns of pure pixels to facilitate error analysis
- Groups of pixels possessing artificially defined statistical distributions
  - e.g. areas of given mean radiance and deviation
    - with along track gradient, cross track gradient, etc.
- Fractal generated scenes for representative studies

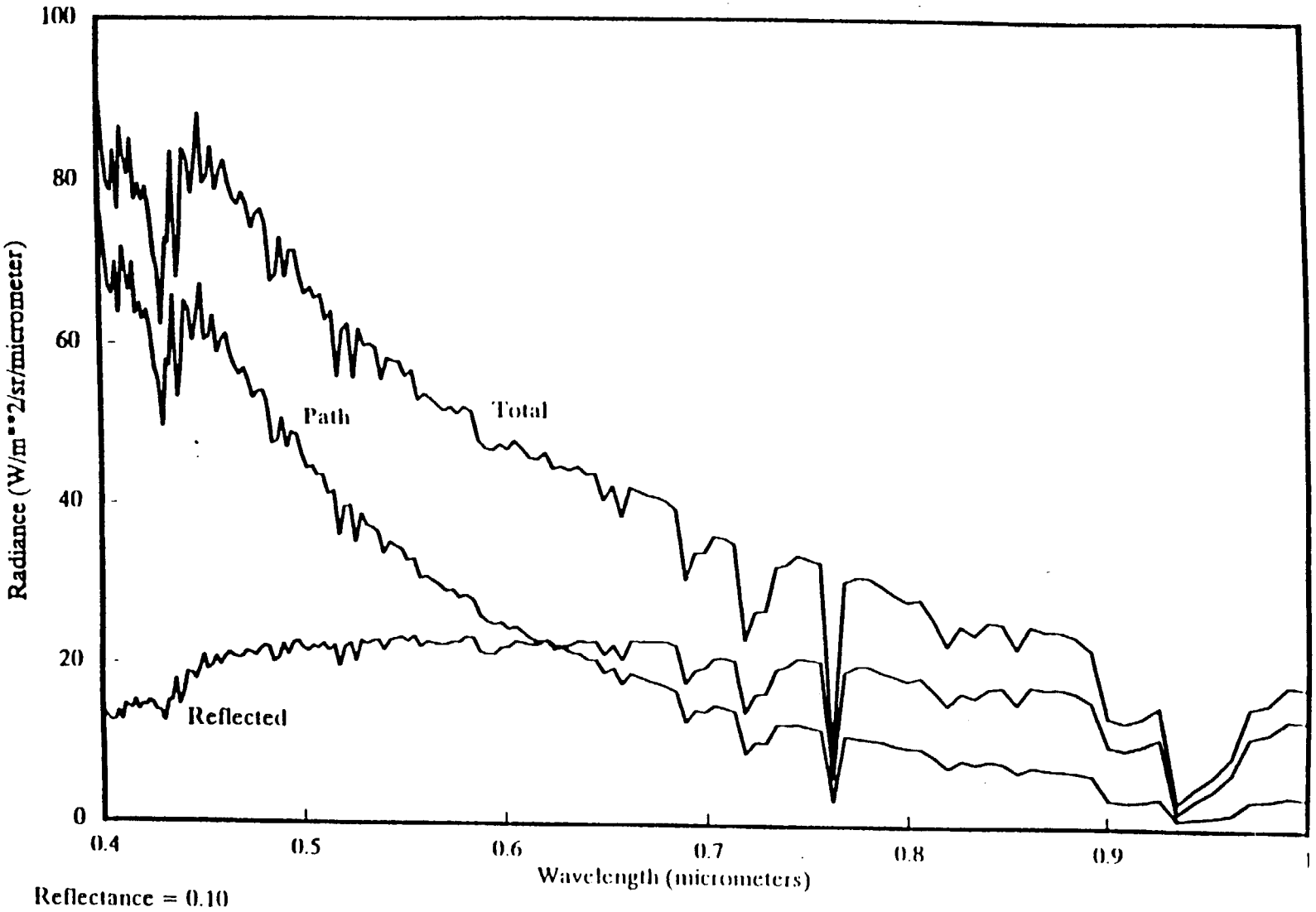
Scenes derived emprically from existing data sets
- Landsat TM, AVHRR, AVARIS, MAS, etc.

UNIX-based PRA shell for simulation activities
that includes modifiable sections for the
- source of irradiance
- scene
- atmosphere
- instrument

Radiance at Top of Atmosphere from LOWTRAN7 Output--1976 US Standard Atmosphere

23Km Visibility -- 1.125 g/cm**2 Water Vapor

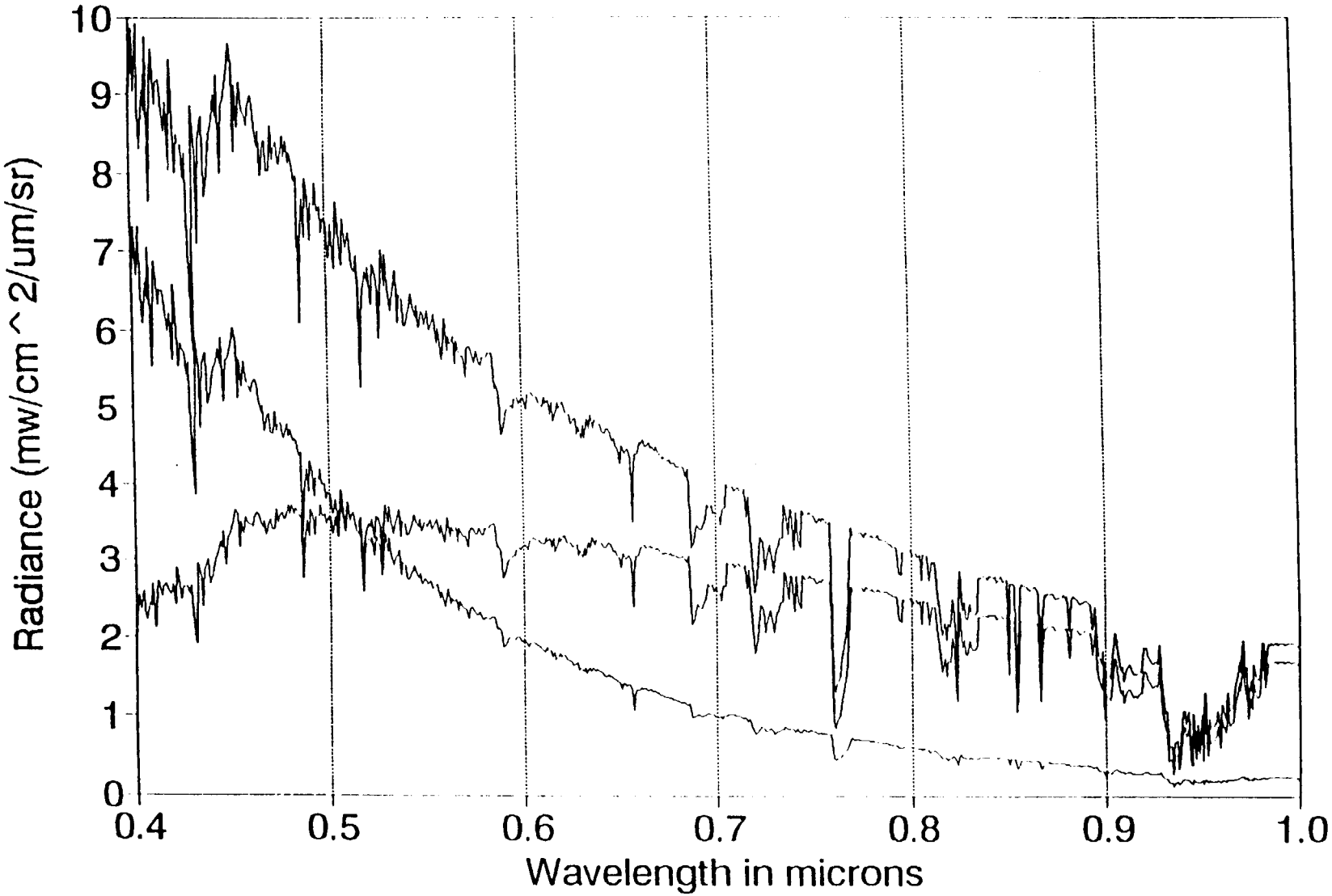
Total, Reflected and Path



Reflectance = 0.10

Radiance at Top of Atmosphere Derived from MCST Spreadsheet Model

Total, Reflected and Path



Global Calibration Site Selection Procedure

Objective

Locate potential MODIS calibration targets on the Earth's surface
that are radiometrically homogeneous on a scale of 3 by 3 Km.

Approach

Initially use annual NDVI biweekly datasets of 1 Km AVHRR data
in the continental United States in 1990
to search for radiometrically homogeneous regions
using the standard deviation of a traveling 3X3 pixel area
as a measure of heterogeneity.

Context

Use calibration sites within the MODIS imagery to provide for
1) every-pass calibration potential
using a modified "radiometric rectification" methodology,
2) aircraft under-flight calibration support, and
3) occasional support of ground field calibration experiments

Schedule

Initial results for 1990 dataset from EDC (EROS Data Center)
were reported at the Calibration Working Group session
of the April 13th MODIS Science Team Meeting

EDC Biweekly AVHRR NDVI Image for Period 6/ 8 to 6/ 21/ 90